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Are Open and Neurotic Behaviors Related to Cognitive Behaviors in Daily Life of Older Adults?

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Abstract

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Keywords: open and neurotic behaviors; cognitive engagement; cognitive complaints; old age; daily life

Are Open and Neurotic Behaviors Related to Cognitive Behaviors in Daily Life of Older Adults?

Assessing human functioning and behavior in laboratory, observational, and daily life settings is central in psychological sciences. Two core domains of human functioning are personality traits and cognition. In laboratory settings, personality traits are usually measured by questionnaires where individuals describe their behaviors and attitudes, while cognition is assessed by performance-based cognitive tasks. In daily life settings, personality-related behaviors are typically measured by daily diaries provided via mobile phones. In terms of cognition, cognitive behaviors such as cognitive engagement and cognitive complaints can also be assessed by daily diaries. When assessing these behaviors on a daily basis, it is important to distinguish the level of analysis because behaviors may differ between and within individuals in daily life (Fleeson & Jayawickreme, 2015). For instance, some individuals might enjoy music (i.e., open behavior) more than others (between-person level), but their tendency to enjoy and listen to music may also vary from day to day (within-person level). Likewise, some individuals might engage more often in cognitive activities (e.g., watching an educational or documentation movie) than others in their leisure time, but a certain individual may also watch two educational movies on one day and no educational movie on the next day and so on. Similarly, people might differ regarding the expressions of their neurotic behaviors (e.g., being moody) and cognitive complaints (e.g., forgetting a grocery item). These expressions may vary from day to day for one specific individual as well.

But how often do older adults complain about their cognitive functioning in daily life? And how often do older adults engage in cognitive activities? Are these cognitive behaviors related to open or neurotic behaviors? Most of the existing studies focused on the between-

person associations between trait measures of personality and cognitive-related constructs, and less emphasis has been put on these associations at the within-person level. The present study thus investigated two different associations in daily life, the association between open behaviors and cognitive engagement as well as neurotic behaviors and cognitive complaints among older adults. We aimed to provide new knowledge about these manifestations and their associations in daily life by describing them at the within-person level.

What We Know So Far

Empirical evidence has shown positive associations between openness and cognitive engagement at the between-person level (cf. Ackerman & Goff, 1994; Soubelet & Salthouse, 2010). Openness is characterized as the general tendency to be curious, creative, sensitive to aesthetics, and open to new ideas and experiences (Costa & McCrae, 1992a). Cognitive engagement can be defined as "an individual's aversion or attraction to tasks that are intellectually taxing" (Ackerman, Kanfer, & Goff, 1995, p. 276). For example, an intellectually taxing activity may be learning a new language (Mascherek & Zimprich, 2012). Previous research suggested substantial positive correlations between openness and cognitive engagement (i.e., r = .44-.70; Ackerman & Goff, 1994). Although researchers discussed on whether openness and cognitive engagement assess the same or different constructs (Ackerman & Goff, 1994; Goff & Ackerman, 1992; Rocklin, 1994), Ackerman and Goff (1994) provided evidence for the differentiation of these two constructs because of the lack of substantial correlations between cognitive engagement and several facets of openness. Thus, openness can be considered a broader personality trait that encompasses more dimensions (e.g., affective, sensory, attitudes, and preferences) than cognitive engagement (Soubelet & Salthouse, 2010). Investment theories, particularly the model of the personality-intelligence interface (Chamorro-Premuzic & Furnham,

2004), postulate that individuals with high levels of openness engage more in intellectual activities that provide learning opportunities, and that this engagement improves cognitive functioning (i.e., crystallized abilities). Moreover, higher levels of openness predicted higher levels of cognitive engagement in older adults (Hogan, Staff, Bunting, Deary, & Whalley, 2012), suggesting that more open adults tend to engage more often in intellectual activities, such as learning about new topics or philosophizing about things.

Previous research also showed positive links between neuroticism and cognitive complaints (Kliegel & Zimprich, 2005; Lane & Zelinski, 2003; Ponds & Jolles, 1996; Wilhelm, Witthöft, & Schipolowski, 2010). Neuroticism is characterized as the general tendency to experience negative emotions such as anger, anxiety, and depression (Costa & McCrae, 1992a). Cognitive complaints can be defined as negative judgments about one's cognition (Mascherek, Zimprich, Rupprecht, & Lang, 2011), which may be frequent among emotionally unstable individuals. That is, individuals who experience more negative emotions such as anger or anxiety (i.e., higher neuroticism) tend to make more negative judgments about their cognition (i.e., higher levels of cognitive complaints). Correlation coefficients for the association between cognitive complaints and neuroticism ranged around $r = .49$ (cf. Kliegel & Zimprich, 2005). A possible explanation might be that neurotic individuals focus on cognitive problems rather than on successful episodes (Ponds & Jolles, 1996). Neurotic individuals may also negatively color self-judgments, both in general and with respect to their cognitive performance (Mascherek et al., 2011). This interpretation is consistent with the "complaint hypothesis" (Wilhelm et al., 2010): High cognitive complaint scores may be an expression of poor self-image or lack of confidence and reflect inappropriate general worry and objectively unjustified complaints. As such, self-reports of cognitive complaints might be biased by negative self-relevant schemata

that increase the activation of failure episodes. This then leads to preferred memory retrieval of such events (Brewin, 2006) that are at least partly irrespective of their absolute or relative frequency or intensity (Wilhelm et al., 2010). Assessing one's own cognition over a short period of time (e.g., one day) may be easier than rating it in reference to longer time frames as done in laboratory studies (e.g., "lately" in Kliegel, Zimprich, & Eschen, 2005; or "compared to earlier" in Mascherek et al., 2011), and thus daily ratings may be less biased. As cognitive performance on average declines (e.g., Lindenberger, & Baltes, 1994; Schaie, 1996), cognitive complaints increase with advancing age (e.g., Abson & Rabbitt, 1988; Zarit, Cole, & Guider, 1981).

What We Need to Know

The majority of the above-mentioned studies have focused on the between-person associations between trait measures of personality and cognitive-related constructs in the laboratory. However, investigating associations at the between-person level *over repeated assessments in daily life* - and not only in the laboratory - helps to better understand how people think and behave, and how changes in thoughts and behaviors are manifested in real life *between* individuals (cf. Allemand & Mehl, 2017; Wrzus, & Mehl, 2015). Furthermore, this approach provides information about interindividual differences in the short-term dynamics (e.g., from day to day) and underlying processes of change or maintenance that typically cannot be covered in laboratory studies (cf. Bolger, Davis, & Rafaeli, 2003; Reis & Gable, 2000), and as they occur in addition to long-term developmental processes (Diehl, Hooker, & Sliwinski, 2015; Noftle & Fleeson, 2010). Briefly, it is essential to grasp daily between-person differences in order to observe human individuality in daily life. Knowledge about such individuality can lead to individually designed intervention strategies.

Furthermore, determining a relationship at the between-person level does not necessarily translate to how these variables are related at the within-person level (e.g., Mroczek, Spiro, & Almeida, 2003; Nezlek, 2011). This means, analyses of between-person associations yield knowledge of important trait variables that distinguish individuals from one another, while analyses of within-person associations yield insights into the dynamic relations between variables and their dependence on situational circumstances (Bolger et al., 2003; Bolger & Laurenceau, 2013). Distinguishing between-person from within-person variability in behaviors related to personality and cognition is important for understanding their stability and change over days. For cognition-personality research, it is important to comprehend what it means for one person to vary from another, and what it means for a person to vary from him or her-self over time (cf. Mroczek et al., 2003).

Studying associations at the within-person level is important for the following reasons. First, investigating associations at the within-person level in daily life helps to better understand how changes in thoughts and behaviors are manifested in real life *within* individuals. In particular, it determines whether the between-person associations are limited to a description of co-occurrences of differences between individuals or can be included in the characterization of the ongoing, internal psychological functioning of individuals. Second, it tests the potential implication of between-person correlations, for example that individuals can become cognitively more engaged by behaving more open, or become cognitively less complaintive by behaving less neurotic, respectively. This means, if this is a potential route to self-improvement, it must be the case that changes within an individual in open behaviors (or neurotic behaviors, respectively) are associated with changes in that individual in cognitive engagement (or cognitive complaints, respectively). Accordingly, possible intervention strategies may be derived and tested in order to

strengthen these associations or to promote adaptive change (e.g., older individuals should be encouraged to maintain their open behaviors if they are related to cognitive engagement).

About the Present Study

The present study investigated two separate research questions. First, we examined the daily associations between open behaviors and cognitive engagement at the between-person and within-person level. Second, we investigated the daily associations between neurotic behaviors and cognitive complaints at the between-person and within-person level. It should be noted that what we know about these associations is largely based on trait measures of openness, neuroticism, and cognitive tendencies (i.e., cognitive engagement and cognitive complaints). In addition, most of this knowledge comes from cross-sectional and/or long-term longitudinal data. However, the present study employed measures of personality-related and cognitive behaviors in daily life. This seems a reasonable approach due to the systematic connection between traits and behaviors. It is namely a core assumption of trait theory that the existence of relatively stable trait attributes of individuals predicts their behavior across time and situations (Johnson, 1997; Kenrick & Funder, 1988). Prior research has shown that Big Five personality traits are systematically related to behaviors (e.g., Ching et al., 2014; Fleeson & Gallagher, 2009; Sherman, Rauthmann, Brown, Serfass, & Jones, 2015). For instance, open individuals act in a more self-revealing way and neurotic individuals behave more nervous (cf. Fleeson & Gallagher, 2009; Fleeson & Wilt, 2010).

Although between-person and within-person analyses can yield different results (Kievit, Frankenhuis, Waldorp, & Borsboom, 2013), a certain isomorphism across these analyses is possible. We expected individuals who report more open behaviors to report more cognitive engagement in daily life (between-person). Moreover, a positive within-person association was

hypothesized: Older adults who report more open behaviors on a particular day were expected to engage in cognitively demanding activities on that same day. The artistic imagination and aesthetic, independent, and nonconforming aspects of open behaviors (cf. De Raad, Hendriks, & Hofstee, 1992; Johnson, 1994) on a specific day may be critical drivers of broader patterns of cognitive activity that lead to cognitive engagement on that day. Furthermore, we expected individuals who report more neurotic behaviors to complain more about their cognition in daily life (between-person). Again, we hypothesized a significant within-person association: Older adults who report more neurotic behaviors on a particular day were expected to report more cognitive complains on that day. The core aspects of neurotic behaviors (e.g., anxiety, worry, anger, and depression; Costa & McCrae, 1992b) on a specific day may negatively color a person's cognition and lead to cognitive complaints on that day. Of further note, we focused on self-reported cognitive behaviors rather than administering cognitive tasks. This was done to investigate naturally occurring behaviors in daily life at the within-person level. In a laboratory setting, individuals' show their maximal performance on a given task. However, in daily life, there is usually no need to perform at the maximum in order to address one's daily demands. Furthermore, open and neurotic behaviors were examined in association with cognitive variables separately as done in prior studies.

Methods

Participants

Participants were drawn from the RHYTHM (Realizing Healthy Years Through Health Maintenance) study in Switzerland. RHYTHM was designed to examine how older individuals actively use and orchestrate multiple stabilization processes and maintenance behaviors in their daily life. A total of 136 healthy older individuals (41.2% male) were recruited via

advertisements in a national newspaper and a database of older adults who are interested in study participations. The mean age of the sample was 70.45 years (*SD* = 6.27, range = 60-91 years). Of the participants, 3.7% attended secondary school with lower school track, 15.4% attended secondary school with higher school track, 3.7% attended secondary school with the Matura graduation (high school), 25.7% attended a university of applied sciences, 20.6% attended university, and 30.9% reported to have another educational background (e.g., vocational training). None of the participants showed signs of (a) cognitive impairment as assessed by the Mini Mental State Examination (MMSE scores < 24; Folstein, Folstein, & McHugh, 1975) or (b) depression as measured by the General Depression Scale (GDS scores < 18; Hautzinger & Bailer, 1993). Perceived health was measured with 12 items concerning the participants' current health situation (Ware, Kosinski, & Keller, 1996). On average, participants reported relatively good health, that is *M* = 1.32 (*SD* = 0.34) on a scale from 1 = *excellent* to 6 = *very poor*.

Procedure

All methods and procedures were approved by the ethics committee for psychological and related research of the University of Zurich. All participants gave their written informed consent prior to study participation. The study lasted a total of 12 days and included three phases: pre-daily assessment (day 1), daily assessments (from day 1 to day 11), and post-daily assessment (day 12). On day 1, participants came to the laboratory for a screening session and completed a series of cognitive tasks and self-report questionnaires (e.g., trait personality). They were also provided with an Android mobile phone and were instructed on how to use the device during the daily assessment phase. An initial group of approximately 20 participants began the study in the same week, a second group started the study two weeks later, a third group started two weeks after the second group and so on.

The daily assessment phase consisted of multiple active and passive assessments per day (up to 3). For the present data analysis, we considered end-of-day assessments. Participants were trigged to answer questions on cognitive and personality-related behaviors[1] on their mobile phone by a ring tone. Rings were timed randomly within a fixed time period, that was between 06:00-09:00 PM. If participants did not respond to a ring, they were reminded after up to a total of ten times. Moreover, participants could decide to delay responding and were then reminded again by a ring tone (within the same time period). The software movisensXS version 4474 (movisens GmbH, 2016) was employed to run the daily questions on the Android mobile phones. Participants were advised to call a study hotline if they experienced problems concerning the mobile phone or had other questions. On day 12, participants attended a final laboratory session during which they returned the mobile phones, filled in the same questionnaires completed at day 1 along with a post-study feedback survey. They were paid 150 Swiss Francs (approx. USD 153) for their participation. The compliance of participants was very high in the present study, they completed at minimum 89% of the evening measurement occasions.

Measures

Daily personality-related behaviors. Every evening, participants rated ten items to report retrospectively on their daily behaviors related to the personality trait openness and ten items related to the personality trait neuroticism. The items came from the daily behavior checklist (DBQ; Church et al., 2008) in which participants check "yes" (1) or "no" (0) for each behavior to indicate whether or not they performed this behavior that day. These behaviors are valid

[1] It should be noted that all Big Five behaviors (openness, neuroticism, conscientiousness, extraversion, and agreeableness) were assessed in the RHYTHM study. However, we focused on open and neurotic behaviors only, because they are theoretically relevant for our cognitive behavior outcomes. This choice built on prior between-person research showing consistent positive associations between openness and cognitive engagement, and between neuroticism and cognitive complaints (as highlighted in the section "What We Know So Far").

indicators of the respective Big Five dimensions (cf. Church et al., 2008). We created a daily summary variable using the mean of each ten items for openness and neuroticism. High scores then indicate more open behaviors (e.g., enjoying music or arts, experiencing intensive feelings, listening to a person who shares other values and opinions) and more neurotic behaviors (e.g., experiencing a lot of stress, being moody, being jealous), respectively.

Daily cognitive engagement. Every evening, participants rated a total of nine items to report retrospectively on their daily cognitive engagement. We used a shortened version of the Typical Cognitive Engagement (TIE) questionnaire (Goff & Ackerman, 1992). The items were selected based on their feasibility in daily life, that is, a balance between rather abstract and rather concrete items was chosen. For example, the item "I focused on an abstract problem" was considered as a rather abstract item. In contrast, the item "I watched an educational or documentation movie" was considered as a rather concrete item. Further items were "I avoided a complicated duty that required thinking" (reverse coded), "I felt competent because I concerned myself with a difficult duty", "I enjoyed thinking about a complicated problem", "I philosophized about things", "I enjoyed thinking about an issue even when the results of my thoughts have no effect on the outcome of the issue", "I listened to a speech", and "I was bored" (reverse coded). Participants were asked to answer the items on a Likert scale ranging from 0 (*strongly disagree*) to 6 (*strongly agree*). High scores indicate a high engagement in intellectual demanding activities. A daily summary variable was created using the mean of these nine items. Following the recommendations of Bolger and Laurenceau (2013), we tested for the within-person reliability of this multi-item scale. We gauged the reliability coefficient omega based on the multilevel confirmatory factor analysis (MCFA; Muthén & Asparouhov, 2011). The within-person reliability estimate omega was .94.

Daily cognitive complaints. Participants rated a total of four items to report retrospectively on their daily cognitive complaints on each evening measurement occasion. The items were adapted from the Nuremberg Self-Assessment List (NSL; Oswald & Fleischmann, 1995). The items were selected based on their feasibility in daily life (i.e., balance between rather abstract and rather concrete items). For example, the item "I had difficulties to focus on a task or to follow a conversation" was considered as a rather abstract item. In contrast, the item "I misplaced or lost an object (e.g., keys, glasses)" was considered as a rather concrete item. Further items were "I had difficulties to remember a name" and "I forgot something (e.g., birthday, grocery item, medication)". Participants rated the items on a Likert scale ranging from 0 (*strongly disagree*) to 6 (*strongly agree*). High scores then indicate more cognitive complaints. A daily summary variable was created using the mean of these four items. The within-person reliability estimate omega was .79.

Covariates. We included age, education, and the general cognitive status (i.e., MMSE score) as potential confounders in our statistical analyses because they share common associations with cognitive engagement (e.g., Soubelet & Salthouse, 2010), cognitive complaints (e.g., Kliegel & Zimprich, 2005), and the personality traits openness and neuroticism (cf. Curtis, Windsor, & Soubelet, 2015; Luchetti, Terracciano, Stephan, & Sutin, 2016). Although we did not expect systematic mean-level changes in our variables, we included time (day) as a covariate because reactivity effects and individual differences over time might be likely to be observed (cf. Bolger & Laurenceau, 2013). We rescaled time such that 0 was the middle day of the 11-day diary period (that is, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5). When time is centered on the middle day, the interpretation of the intercept is the estimate of an individual's average score on the outcome. Trait openness was included as a covariate when testing the association between open behaviors

and cognitive engagement and trait neuroticism was added in the model examining neurotic behaviors and cognitive complaints. Trait openness and neuroticism were measured using the Big Five Inventory (John, Naumann, & Soto, 2008) on day 1 (pre-daily assessment). The items were rated on a 7-point Likert scale ranging from 0 (*strongly disagree*) to 6 (*strongly agree*). For openness (10 items), Cronbach's alpha was .75, whereas the omega hierarchical estimate (Zinbarg, Revelle, Yovel, & Li, 2005) was .40. For neuroticism (8 items), Cronbach's alpha was .84 and the omega hierarchical estimate was .78. Except for the omega of openness, the internal consistencies of both measures ranged from acceptable to good.

Statistical Analyses

Our data exhibited a nested structure: Daily observations (Level 1) were nested within participants (Level 2). For this reason, we used multilevel modeling (Bolger & Laurenceau, 2013; Raudenbush & Bryk, 2002; Snijders, & Bosker, 1999) to investigate our research questions. The analyses were performed in three steps. First, unconditional random-intercept-only models without predictors were estimated to calculate the intraclass correlation coefficients (ICCs). The ICC represents the proportion of between-person variance relative to the total variance (Nezlek, 2011). If the ICC is low, there is no need to use multilevel modeling as the individuals do not differ from each other in a meaningful way. Second, random-intercept-random-slope models without covariates were calculated. Third, conditional random-intercept-random-slope models were tested, this means the covariates age, education, general cognitive status, trait openness or neuroticism, respectively (all grand-mean centered), and time (centered on the middle day) were added to investigate the associations between open behaviors and cognitive engagement as well as neurotic behaviors and cognitive complaints. In addition, we examined possible cross-level interactions in the conditional random-intercept-random-slope

models (Raudenbush & Bryk, 2002). In the present two-level data structure, a cross-level interaction occurs when a relationship between two level-1 (within-person) variables varies as a function of a level-2 (between-person) variable (Nezlek, 2011). Hence, we investigated whether our level-2 variables age, education, general cognitive status, trait openness or neuroticism, respectively, moderated the associations of interest.

In the analyses, we included a between-person version and a within-person version of the predictors to control for the between-person effects and to truly examine the within-person variation (cf. Bolger & Laurenceau, 2013). The between-person versions correspond to the person-means of the predictors. The within-person versions of the predictors were computed by subtracting the person-means from the grand-mean centered variables.

The statistical models were estimated in Mplus 8 (Muthén & Muthén, 1998-2017), using a Bayesian estimator. Model estimation was performed with 1,000 iterations using two Markov Chain Monte Carlo (MCMC) methods, the Gibbs sampler and with a default of diffuse (non-informative) priors. The details of the technical implementation are described in Muthén and Muthén (1998-2017, pp. 668-669, 701-707, 775). The models reached an appropriate convergence criterion of Proportional Scale Reduction (PSR) < 1.09. A PSR of < 1.10 indicates an acceptable convergence level, whereas a PSR of 1.00 is considers perfect model convergence (Kaplan & Depaoli, 2013). The proportion of variance explained was quantified by the summary statistic pseudo R^2. Pseudo R^2 is the proportional reduction in residual variance between two models, therefore, it is an indicator of how much added predictors explain unexplained outcome variation.

Results

Analyses were performed on 1,333 to 1,375 available observations, out of theoretically possible 1,496 observations (136 participants × 11 days). Missing data ranged from 8.1% to 10.9% depending on the variables of interest. Table 1 presents the descriptive statistics and between-person as well as within-person correlations among the variables of interest[2].

Unconditional Random-Intercept-Only Models (Step 1)

The random effect variance of open behaviors indicated significant variation at the within-person level (*Var* = .02, $p < .001$). The ICC of open behaviors was .50, indicating that 50% of the total variance lied between-persons and 50% lied within-persons. For neurotic behaviors, significant variation at the within-person level (*Var* = .01, $p < .001$) was found. The ICC of neurotic behaviors was .27, hence indicated that 27% of the total variance lied between-persons and 73% lied within-persons. The variation at the within-person level was significant for both cognitive variables, i.e., engagement (*Var* = .39, $p < .001$) and complaints (*Var* = .50, $p < .001$). The ICC of both cognitive variables was .49, thus indicated that 49% of the total variance for each of these variables lied between-persons and 51% lied within-persons. In sum, all ICCs were relatively high and justified the use of multilevel modeling.

Random-Intercept-Random-Slope Models Without Covariates (Step 2)

Next, the models without covariates were estimated. Note that standard deviations (*SD*) refer to the Bayesian posterior standard deviations and *p*-values are one-tailed. Confidence intervals are shown in brackets. The estimates are standardized estimates (μ_β).

[2] Neurotic behaviors and cognitive complaints tended to be positively skewed. To make sure that the results are not biased by the distribution of the variables, we used the log-transformation to reduce positive skew and ran all analyses with the transformed variables. The results changed minimally, but not concerning the gist. Neurotic behaviors were unrelated to cognitive complaints at the between-person level ($\mu_\beta = 0.10$, *SD* = 0.07, $p = .056$, 95% [CI -0.028, 0.238]). Time was related to daily cognitive complaints ($\mu_\beta = -0.22$, *SD* = 0.11, $p < .05$, 95% [CI -0.425, -0.007]), whereas the other covariates were not. The random effect of the slope was $\mu_\beta = 0.04$ (*SD* = 0.02, $p = .081$, 95% CI [-0.016, 0.073]), indicating that days of neurotic behaviors were unrelated to cognitive complaints on the same days within individuals. We did not find any significant cross-level interactions. The results of the random effects showed that participants significantly differed in their intercepts of daily cognitive complaints and in the time-slope.

Open behaviors and cognitive engagement. Daily open behaviors were positively associated with daily cognitive engagement at the between-person level ($\mu_\beta = 0.45$, $SD = 0.05$, $p < .001$, 95% CI [0.334, 0.548]). This suggests that an increase of one-unit in open behaviors was associated with an increase of 0.45 in daily cognitive engagement. Moreover, the within-person regression of cognitive engagement on open behaviors was $\mu_\beta = 0.17$ ($SD = 0.02$, $p < .001$, 95% CI [0.123, 0.215]), indicating that within individuals, days of more open behaviors were significantly related to more cognitive engagement behaviors on the same days, and that days of fewer open behaviors were significantly related to fewer cognitive engagement behaviors on the same days.

Neurotic behaviors and cognitive complaints. Daily neurotic behaviors were not related to daily cognitive complaints at the between-person level ($\mu_\beta = 0.13$, $SD = 0.06$, $p = .025$, 95% CI [-0.001, 0.250]). Likewise, the within-person regression was not significant ($\mu_\beta = 0.21$, $SD = 0.02$, $p = .168$, 95% CI [-0.020, 0.067]), indicating that days of neurotic behaviors were unrelated to cognitive complaints on the same days within individuals.

Conditional Random-Intercept-Random-Slope Models (Step 3)

Subsequently, we added the covariates (age, education, general cognitive status, time, and trait openness or neuroticism, respectively) to the models. Tables 2 and 3 show the standardized fixed and random effects of the conditional models. All intercepts and slopes were modeled as random effects (Bolger & Laurenceau, 2013).

Open behaviors and cognitive engagement. Daily open behaviors were positively associated with daily cognitive engagement at the between-person level (see person-mean open behaviors in Table 2). This suggests that an increase of one-unit in open behaviors was associated with an increase of $\mu_\beta = 0.42$ in daily cognitive engagement ($SD = 0.06$, $p < .001$, 95%

CI [0.289, 0.513]). Time was significantly related to daily cognitive engagement, whereas the others covariates were not. The predicted increase in the intercept of cognitive engagement was μ_β = -0.34 for a one-unit increase in time (*SD* = 0.17, $p < .05$, 95% CI -0.733, -0.041]). This suggests that for every one-unit increase in time, there was decrease of 0.34 in daily cognitive engagement and may be interpreted as a reactivity effect, that, however, did not affect our main results. In Table 2, the variable "slope" is of focal interest as it is defined by the within-person regression of cognitive engagement on open behaviors (cf. Finch & Bolin, 2017). The random effect of the slope was $\mu_\beta = 0.16$ (*SD* = 0.03, $p < .001$, 95% CI [0.103, 0.203]), indicating that within individuals, days of more open behaviors were significantly related to more cognitive engagement behaviors on the same days, and that days of fewer open behaviors were significantly related to fewer cognitive engagement behaviors on the same days.

In addition, we observed a significant cross-level interaction: Age moderated the effect of open behaviors on cognitive engagement (μ_β = -0.31, *SD* = 0.14, $p < .01$, 95% CI [-0.594, -0.048]). The association between open behaviors and cognitive engagement was stronger in young-old adults. Specifically, for young-old adults (< 70.45 years), the effect was $\mu_\beta = 2.37$ (*SD* = 0.03, $p < .001$, 95% CI [0.157, 0.280]), while for old-old adults (>70.45 years), the effect was $\mu_\beta = 0.08$ (*SD* = 0.04, $p = .026$, 95% CI [-0.001, 0.153]). Moreover, the results of the random effects showed that participants significantly differed in their intercepts of daily cognitive engagement. Time yielded also a significant value, suggesting that participants differed in the time-slope.

Lastly, the Pseudo R^2 was calculated by comparing the two models for open behaviors and cognitive engagement (Step 2 and Step 3). The pseudo R^2 is an indicator of how much (in percentage) the conditional random-intercept-random-slope model (Step 3) improves upon the

model without covariates (Step 2) by reducing the residual variance of the outcome variable. The conditional random-intercept-random-slope model (Step 3) has led to an improvement compared to the model without covariates (Step 2) by reducing the residual variance of cognitive engagement by 2.4% (between-person) and 3.7% (within-person).

Neurotic behaviors and cognitive complaints. Daily neurotic behaviors were unrelated to daily cognitive complaints at the between-person level (see person-mean neurotic behaviors in Table 3). Time was significantly related to daily cognitive complaints, whereas the other covariates were not. The predicted increase in the intercept of cognitive complaints was μ_β = -0.34 for a one-unit increase in time (*SD* = 0.16, $p < .05$, 95% CI [-0.701, -0.067]). This suggests that for every one-unit increase in time, there was a decrease of 0.34 in daily cognitive complaints. The random effect of the slope was μ_β = 0.03 (*SD* = 0.02, $p = .149$, 95% CI [-0.025, 0.069]), indicating that days of neurotic behaviors were unrelated to cognitive complaints on the same days within individuals. We did not find any significant cross-level interactions. However, the results of the random effects showed that participants significantly differed in their intercepts of daily cognitive complaints and in the time-slope.

The conditional random-intercept-random-slope model (Step 3) improved upon the model without covariates (Step 2) by reducing the residual variance of cognitive complaints by 4.2% (between-person) and 5.7% (within-person), respectively.

Discussion

In line with our hypotheses, we found a positive association between daily open behaviors and daily cognitive engagement at both level of analysis. The between-person association suggests that individuals differed from each other in their daily levels of open behaviors and cognitive engagement. Thus, our results support previous between-person findings

(e.g., Ackerman & Goff, 1994; Chamorro-Premuzic & Furnham, 2004; Hogan et al., 2012; Soubelet & Salthouse, 2010), and show that these associations also hold within individuals over eleven days. On days when participants behaved more openly, they were more engaged in cognitive activities or on days when they behaved less openly, they reported lower cognitive engagement. Interestingly, age moderated the within-person relationship between open behaviors and cognitive engagement. For young-old adults (< 70.45 years), the effect of open behaviors on cognitive engagement was stronger than for old-old adults (> 70.45 years). It seems possible that young-old individuals may face more opportunities to behave openly and to show more cognitive investment in their daily life than older individuals, thus enhancing a stronger within-person association. For instance, they may have a larger social network that increases the probability to talk about things from different perspectives, to listen to a person who shares other values/opinions or to try novel activities. It may also be that old-old adults have more age-related issues (e.g., lower MMSE scores) compared to younger-old adults, which could limit the adoption of open-related behaviors.

In contrast to our expectations, individuals who reported more neurotic behaviors did not complain more about their cognition at the daily between-person level. This finding is contrary to previous laboratory-based between-person studies showing that neurotic individuals may negatively color their cognition (Mascherek et al., 2011) and/or focus on cognitive problems (Ponds & Jolles, 1996). This could be good news for neurotic people in the sense that they are not more prone to experiencing cognitive complaints in daily life. The inconsistency between previous and our results may be due to the different context in which neuroticism and neurotic behaviors were assessed. Indeed, phenomena demonstrated in the laboratory may not actually occur in the real world (Bolger & Laurenceau, 2013). A possible explanation for this

disconnection may be the retrospective and generalized responses in self-reports conducted in the laboratory. These self-reports may be biased by memory processes and cognitive heuristics, and they leave open the possibility that people respond on the basis of what they consider typical (Schwarz, 2012). As such, individuals refer to their typical cognitive failure when they rate their general cognitive complaints in the laboratory, and they thus may overestimate them compared to if their actual behaviors are assessed on a daily basis. However, it should also be noted that our sample was healthy and cognitively unimpaired. Our participants did not report a lot of neurotic behaviors and cognitive complaints (floor effect). Hence, the current results should be replicated in a less healthy sample. Furthermore, it seems possible that associations between neurotic behaviors and cognitive complaints are only evident in individuals who suffer from mild cognitive impairment or dementia or who are highly neurotic. Put differently, it can be assumed that as long as neurotic individuals are healthy and report some minor daily cognitive hassles only, there seems to be no significant link. This may also be a possible explanation for the lack of significance at the within-person level. On days when older adults reported more neurotic behaviors, they did not systematically report more cognitive complaints. As such, negative aspects of neurotic behaviors on a specific day do not seem to negatively color a healthy person's cognition and lead to cognitive complaints on that day. Future studies that consider group comparisons (healthy and cognitively impaired individuals) are necessary to support this assumption. There may also be different mechanisms underlying these linkages at each level of analysis which is an important issue for future research.

The present findings may have important implications. In regard to between-person associations, people varied from one another in their daily levels of open behaviors and cognitive engagement. Some people reported higher levels than others, whether due to internal or external

circumstances. These individual differences are important for professionals involved in providing personality-centered or cognitive interventions to older adults. This means, not everyone who participates in an intervention is equivalent, and an intervention that works for one individual may not work for another. With respect to within-person implications, our results suggest that individuals have the flexibility and opportunity to act in different ways (i.e., behave more or less openly) that in turn may bring about personally desired consequences (i.e., higher cognitive engagement) (cf. Fleeson, Malanos, & Achille, 2002). At a general level, this is in line with the "doing" view of personality (Cantor, 1990). In other words, daily cognitive engagement is conditional on what individuals are doing (i.e., open behaviors). Therefore, individuals are able to influence desired outcomes through their behaviors. In that sense, it is possible that a simple intervention with the goal to encourage individuals to act more openly may be successful to increase their cognitive engagement (and vice versa). In turn, cognitive engagement may positively influence cognitive functioning in older age (e.g., Wilson et al., 2002; Wilson, Segawa, Boyle, & Bennett, 2012). As such, open behaviors may reflect a pathway by which cognitive engagement bestows an advantage in cognitive functioning in later life (Sharp, Reynolds, Pedersen, & Gatz, 2010; Soubelet & Salthouse, 2010). Before it can be established as useful, the causality of these relationships, the possible mediating role of cognitive engagement, and its applicability to personality and cognitive interventions need to be established. But the first and critical step, showing that these processes with regard to open behaviors and cognitive engagement do occur within older adults, has now been taken.

It should be noted that this finding is relevant not only to those who have a need to increase their cognitive engagement (e.g., individuals who realize that their cognitive abilities decline and want to "fight against it" or want to improve their cognitive performance), but also to

cognition-personality research. Why? If between-person associations also hold at the within-person level, useful opportunities may be provided. First, variation in daily behaviors may be more rapid to observe than change in traits (cf. Fleeson et al., 2002). Whereas an ambulatory assessment study (to examine variation in daily behaviors) can be conducted over several days or weeks, a longitudinal study (to investigate change in traits) needs to be conducted over several months, years or decades. Hence, cognition-personality research may gain knowledge (or suggestions for future work) more rapidly from ambulatory assessment studies if isomorphism is confirmed. Second, methods of experimental control could be applied at the within-person level. To the extent that behaviors have the same properties as traits, researchers should be able to randomly assign individuals to behaviors and instruct them to behave in those ways (Fleeson et al., 2002). Thus, cognition-personality research may gain valuable information for possible intervention strategies by applying experimental manipulation of behaviors.

The present study makes three noteworthy contributions. First, a real-life research design was applied to assess the within-person associations of interest. Second, behaviors were captured in daily life rather than artificially forming groups of individuals (e.g., high and low neuroticism) that may not adequately represent how individuals behave in their everyday life. Third, the daily assessments provide ecological validity. Participants responded to self-report questions at the end of each day. This was a first attempt to examine the associations of interest at the daily within-person level. Nevertheless, there are opportunities for future research. In particular, behaviors related to personality and cognition may be assessed more frequently each day to receive a fine-grained picture of how the associations unfold in daily life. It seems also worthwhile to extend the present time-triggered approach and employ event-triggered assessments. For example, participants may be instructed to rate a behavior each time they engage in that particular

behavior such as enjoying music. Importantly, the present study was correlational and descriptive in nature, and causality was not established. In our multilevel modes, we looked only in one direction, that is from personality-related behaviors toward cognitive behaviors. It is also possible that cognitive behaviors influence personality-related behaviors. Future studies that either manipulate frequency of personality-related behaviors or intervene on cognitive variables are necessary to disentangle the bidirectional relationship and to reveal causal directionality. Lastly, our sample size was rather modest to investigate level-2 associations using between-person variables (age, education, MMSE, trait openness and neuroticism), however, our focus was to examine the level-1 associations using within-person variables. Nevertheless, our level-2 associations using between-person variables should be interpreted with caution.

To conclude, the present study significantly contributes to the research field of personality-cognition interrelations by providing support for positive associations between open behaviors and cognitive engagement both at the between-person and within-person level. Hence, our results inform on possible intervention strategies: For instance, encouraging young-old individuals to act more openly may be successful to increase their cognitive engagement. However, neurotic behaviors and cognitive complaints were unrelated at both levels of analysis. These findings suggest that conclusions drawn from laboratory research may not necessarily hold in daily life. Further work is needed to better understand how, when, and why these behaviors are linked (or not) in daily life.

Declaration of Conflicting Interests

The authors declare no potential conflicts of interest concerning the research, the authorship, and publication of this article.

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Table 1

Descriptive Statistics and Between-Person and Within-Person Correlations among the Study Variables

Variables	*M*	*SD*	Range	1	2	3	4	5	6	7	8	9
1. Open behaviors	0.29	0.18	0-1	–	.19 ***	-.01	.05	–	–	–	–	–
2. Cognitive engagement	3.11	0.87	0-6	.54 ***	–	-.03	.04	–	–	–	–	–
3. Neurotic behaviors	0.12	0.09	0-1	.12 ***	-.06 *	–	.03	–	–	–	–	–
4. Cognitive complaints	0.99	0.98	0-6	.02	.07 **	.18 ***	–	–	–	–	–	–
5. Age	70.45	6.27	60-91	.09 ***	.02	.00	.20 ***	–	–	–	–	–
6. Education	4.64	1.53	0-7	.07 **	.20 ***	-.18 ***	.01	-.02	–	–	–	–
7. MMSE	27.79	1.15	0-30	.02	-.08 **	-.01	-.17 ***	-.24 **	.24 **	–	–	–
8. Trait openness	4.25	0.79	0-7	.26 ***	.32 ***	-.07 **	-.35 ***	-.24 **	.36 ***	.01	–	–
9. Trait neuroticism	2.05	1.09	0-7	.03	-.11 ***	.40 ***	.19 ***	.06	-.02	-.07	-.27 **	–

Note. N_1 = 136 participants, N_2 =1,333 to 1,375 observations. Because daily variables include both within- and between-person variance, we provide both within- and between-person correlations for them. The daily between-person variables refer to the within-person means. Between-person correlations are reported below the diagonal and within-person correlations are shown above the diagonal. MMSE = Mini Mental State Examination; *M* = mean; *SD* = standard deviation. Range refers to the possible range of variable scores, except for age that represents the actual age range. Education was assessed on an ordinal scale ranging from 0 (no education) to 7 (university).

*$p < .05$, **$p < .01$, ***$p < .001$.

Table 2

Bayesian Parameter Estimates of Multilevel Model of Open Behaviors on Cognitive Engagement

	μ_β		*SD*	95% CI
Fixed effects				
Intercept	5.50	***	0.37	[4.788, 6.272]
Slope	1.00	***	0.37	[0.503, 1.988]
Person-mean open behaviors	0.42	***	0.06	[0.289, 0.513]
Age	-0.03		0.06	[-0.154, 0.090]
Education	0.12		0.06	[-0.015, 0.234]
MMSE	-0.09		0.06	[-0.203, 0.037]
Trait openness	0.12		0.07	[-0.013, 0.249]
Time	-0.34	*	0.17	[-0.733, -0.041]
Slope × age	-0.31	**	0.14	[-0.594, -0.048]
Slope × education	0.09		0.13	[-0.177, 0.336]
Slope × MMSE	0.01		0.11	[-0.190, 0.234]
Slope × trait openness	0.12		0.16	[-0.168, 0.436]
Random effects				
Intercept	0.78	***	0.05	[0.680, 0.864]
Slope	0.16	***	0.03	[0.103, 0.203]
Residuals	0.90	***	0.02	[0.863, 0.932]
Time	-0.06	*	0.03	[-0.114, -0.012]

Note. N_1 = 136 participants, N_2 = 1,341 observations. MMSE = Mini Mental State Examination; *SD* = posterior standard deviation; 95% CI = 95% confidence intervals. Slope represents a latent variable that is defined by the within-person regression of open behaviors on cognitive engagement and may vary across between-person predictors. The random effect estimates were represented by random effect variances.

*p < .05, **p < .01, ***p < .001; p-values are one-tailed.

Table 3

Bayesian Parameter Estimates of Multilevel Model of Neurotic Behaviors on Cognitive Complaints

	μ_β		*SD*	95% CI
Fixed effects				
Intercept	1.41	***	0.13	[1.138, 1.654]
Slope	0.22		0.27	[-0.290, 0.758]
Person-mean neurotic behaviors	0.11		0.07	[-0.036, 0.236]
Age	0.12		0.06	[-0.007, 0.231]
Education	0.05		0.06	[-0.073, 0.175]
MMSE	-0.10		0.07	[-0.227, 0.027]
Trait neuroticism	0.08		0.07	[-0.048, 0.217]
Time	-0.34	**	0.16	[-0.701, -0.067]
Slope × age	-0.16		0.17	[-0.505, 0.199]
Slope × education	0.04		0.17	[-0.236, 0.493]
Slope × MMSE	-0.07		0.16	[-0.379, 0.249]
Slope × trait neuroticism	0.15		0.17	[-0.147, 0.578]
Random effects				
Intercept	0.94	***	0.03	[0.871, 0.980]
Slope	0.03		0.02	[-0.025, 0.069]
Residuals	0.92	***	0.02	[0.890, 0.955]
Time	-0.08	**	0.03	[-0.131, -0.028]

Note. N_1 = 136 participants, N_2 = 1,333 observations. MMSE = Mini Mental State Examination; *SD* = posterior standard deviation; 95% CI = 95% confidence intervals. Slope represents a latent variable that is defined by the within-person regression of neurotic behaviors on cognitive complaints and may vary across between-person predictors. The random effect estimates were represented by random effect variances.

*p < .05, **p < .01, ***p < .001; p-values are one-tailed.